VII. MAGNETIC RESONANCE*

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A. HIGH RESOLUTION NUCLEAR MAGNETIC RESONANCE IN SOLIDS

A multiple-pulse NMR experiment (Wahuha method) employing a repeated four-pulse cycle, proposed earlier,[1] has been successfully tested.[2] In solid CaF_2 the ^{19}F resonance has been effectively narrowed to approximately 60 Hz. Further narrowing in that experiment is prevented at present by (a) inhomogeneity of the Zeeman field (largely because of sample and probe geometry), (b) inhomogeneity of the radiofrequency field, (c) finite pulse width, and (d) finite pulse spacing.

A general theory of magnetic resonance in the presence of rapidly modulated external fields has been developed in which the time development of the spin system is followed in a time-dependent interaction representation and developed as a perturbation series in t_c/T_2, where t_c is the period of the modulation, and T_2 is a natural time of the spin system. Application of this theory shows that difficulties (b) and (c) of the Wahuha experiment can be removed to first order by means of an eight-pulse cycle (the eightfold way), which consists in a doubling of the original four-pulse cycle with RF phase reversal in the second half. A pulse programmer and RF gating system for this experiment has been built and tested.

The general theory also suggests a pulsed version of the Lee-Goldburg experiment,[3] mentioned in Quarterly Progress Report No. 88 (page 76). This experiment has been performed in CaF_2 with narrowing equal to that obtained by Lee and Goldburg, but with the advantages that the induction signal is observed "continuously" and less attention need be paid to the generation of a very homogeneous RF field.

The theory shows that the Wahuha and eightfold-way experiments have an advantage over the Lee-Goldburg experiment for finite t_c, in that the lowest order correction terms vanish for the former but not for the latter. The same improvement is predicted for the Lee-Goldburg experiments, cw or pulsed, by periodic reversal of direction of the effective field in the rotating frame. Such experiments are now in progress.

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References

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